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WHAT IS NEEDED FOR FUTURE 3D PRINTING FROM MAKER'S VIEWPOINTS

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ABSTRACT

This study focused on investigating makers' opinions about current 3D printing technology to foster the development and use of 3D printing technologies in Taiwan. 3D printing has revolutionized the manufacturing industries as it provided a highly flexible, customizable way of small-quantity production at low cost. Its popularity among general users, however, encountered difficulties such as high requirements in skills, less user-friendliness, lack of practicality, low reliability, etc. Makers, a special group of customers of 3D printers are familiar with problems of this technology as they shared experience on the Internet, started collaborative manufacturing with open sources and turned their DIY activities into E-business. The study utilized questionnaires in the makers' space to obtain the background of this special group of customers, their viewpoints regarding important features to consider for purchasing a 3D printer, and difficulties and solutions in propagation of 3D printing. The results demonstrated that makers were a group of extrovert and intuitive thinkers in terms of MBTI personalities and treasured printing precision (surface quality), stability (long tuning period) and easy maintenance as most attractive factors to customers. From their viewpoints, difficulties in use, customers' low interests, and lack of practicality of its products were rated top 3 problems for 3D printing. However, school education, propagation of makers' space and development of ease-to-use 3D software may help its popularity. The results of this study may help 3D printer manufacturers and 3D printing service providers to better understand their customers' behaviors, based on which better 3D printing services and 3D printers can be developed to improve their business.

Keywords: 3D printing, makers, customer behavior, MBTI personality

INTRODUCTION

3D Printing and Makers

3D printing has revolutionized the manufacturing industries as it provided a highly flexible, customizable way of small-quantity production at low cost [1,2]. More importantly, many innovative and creative ideas can be implemented quickly through it without considerable investment. Maker movement has played an important role in this manufacturing revolution. Makers, a special group of people who utilized open sources on the Internet, performed active learning and shared experience in DIY with each other [3]. 3D printing is one of the most used manufacturing methods by makers and makers constituted a major group of users in 3D printing. 3D printing, however, seemed to have difficulty in popularization due to many reasons: high requirements in skills, less user-friendliness, lack of practicality, low reliability, etc. Since makers are the users who are familiar with 3D printing the most, their experience in using 3D printers and thoughts about obstacles in current 3D printing should be consulted to develop future 3D printing technologies, making 3D printers more suitable for the public use.

It is known that 3D printing has transformed some traditional manufacturing into non-traditional manufacturing such as collaborative manufacturing and social manufacturing [4]. Maker space, for example, is the place where 3D printing technology is mostly used and explored to implement social manufacturing. Ideas are quickly exchanged in the maker space and realized by 3D printing which shortens the lapse from the design to the prototyping significantly [5]. Prototypes manufactured by 3D printing in the maker space facilitate crowdfunding as everyone not only see visual presentations of products but also touch and feel their physical samples. In addition, they can be quickly modified and re-produced. Therefore, the maker space is a true incubator of innovations, and 3D printing is one key technology enables its revolution. However, whether its impact can propagate depends on its evolution. A customer survey has revealed that only 4% of the respondents were females, and the most 3 appealing features to 3D printing consumers were bigger build volume, faster printing speed, and more extruder heads [6]. The users' demographics and needs are relevant to the future of 3D printing because they indicates what kind group of people should be focused on, and what characteristics should be pursued in order to keep 3D printing alive or even make it more prosperous in the general public. Such a survey, however, was never conducted in Taiwan.

Literature Review

The maker magazine has conducted a survey in 2013 on its customer for 3D printing's status quo. The results showed that 65% of respondents regarded themselves as amateurs. Most of them used 3D printers on personal projects (61%), but mixtures who used 3d printing on both work and personal use also occupied 39%. about half respondents (46%) owned or used 3D printers frequently, and they had used 3D printers in the past week. Some 3D printing "haters" criticized 3D printers as cheap desktop manufacturing machines, but most of them appreciated that 3D printers can be used to produce cheap but practical commodities. As for things to print, 76% of respondents chose prototypes for projects, 75% manufactured components for real

applications, and another 64% of respondents made parts for maintenance purposes. For market shares, MakerBot was the most known brand (91%), followed by Printrobot (50%), 3D Systems (43%), UltiMaker (42%), Formlabs (41%) and Lulzbot (41%). It was also found from the investigation that the most valued characteristics of 3D printers were low cost/performance value (85%), durability/stability (83%), output quality (82%), ease-to-use (67%) and no need of cares after printing has started (64%). Such a survey, however, was never conducted in Taiwan.

METHOD

The study was conducted through a contextual questionnaire on-site in the maker space. The questionnaire included single- and multiple-answer questions regarding the makers' gender, age, occupation, income, activities liked and experience in 3D printing. In addition, there were open questions for their opinions about the current and future 3D printers including reasonable pricing, obstacles to their popularity and possible countermeasures. Descriptive statistics were performed to analyze the data. There was also a special section where the questionnaire respondents played a card-sorting game to reveal the most appealing characteristics of 3D printers. The results of card-sorting section were weighted according to each characteristic's ranking in one of the four groups: unnecessary, not important, important and very important. The respondents' personalities were also tested with an embedded MBTI test. A partial questionnaire is shown in Figure 1.

Part I : Characteristics of Makers

1. Background Information

- (1) Gender Male Female
- (2) Age <18 18-20 21-29 30-39 40-49 50-59 >60
- (3) Occupation Student Public Servant Construction
Commerce/Finance/Trading Wholesale/Retail
Medical Service/Social Service Agriculture/Forestry/Fishery/Livestock
 Farming/Mining General Service Industry Technical Service/Research
Performing/Art/Cultural and Creative Business Others(_____)
- (4) Personal Annual Income Under 500k 510-750K 760-1000K 1000-1500K
1500-2000K Above 2000K Unfixed

(5) Leisure activities	Dislike	Okay	Like	Enjoy
Literature and art	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sports and exercises	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Entertainment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shopping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Travelling abroad	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Domestic Travelling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Indoor Activities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Watching TV and surfing on the Internet	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. Experience in 3D Printing

- (1) For how long have you used 3D printing? Never (Please jump to (8)) less than 3 months 3-6 months 6 months-1 year 1-2 years More than 2 years
- (2) How frequent do you use 3D printing? More than 1 time per week About 1 time per week More than one time per month Less than one time per month
- (3) For what do you use 3D printing?(multiple-answer) Produce my own work Making 3D printers Making commercial products Learning knowledge and skills about 3D printing Other_____
- (4) What are the things that you have printed?

- (5) Do you have your own 3D printer? Yes(It costs NTD\$_____)
No , I use one in _____ °
 Why do not you own one? _____

Figure 1. Questionnaire used in the study (part I)

RESULTS

86.7% of makers were males and 46.7% of makers were in their 30-40s. Also 26.7% were in cultural and creative business, which occupied the largest portion of makers' occupation (Figure 2). Surprisingly, most makers preferred sports/exercises and travelling to shopping and indoor activities. They revealed to be extroverted, intuitive, and tended to be thinkers in terms of MBTI personalities. Various types of products were manufactured by surveyed makers. The most common type of products is parts (e.g. mechanical parts) and models (e.g. product prototypes). The second type of products is commodities for daily use, such as decorative components, toys, widgets, etc. Cultural and creative products were classified in to the third type, and most of them are dolls and sculptures. The number of real commercial products manufacture by 3D printers was pretty limited due to their surface quality requirements, i.e. 3D printing cannot fulfill the surface precision needed for most products. Interestingly, half surveyed makers did not have their own 3D printers, signifying their conservative attitudes for 3D printers' practical use.

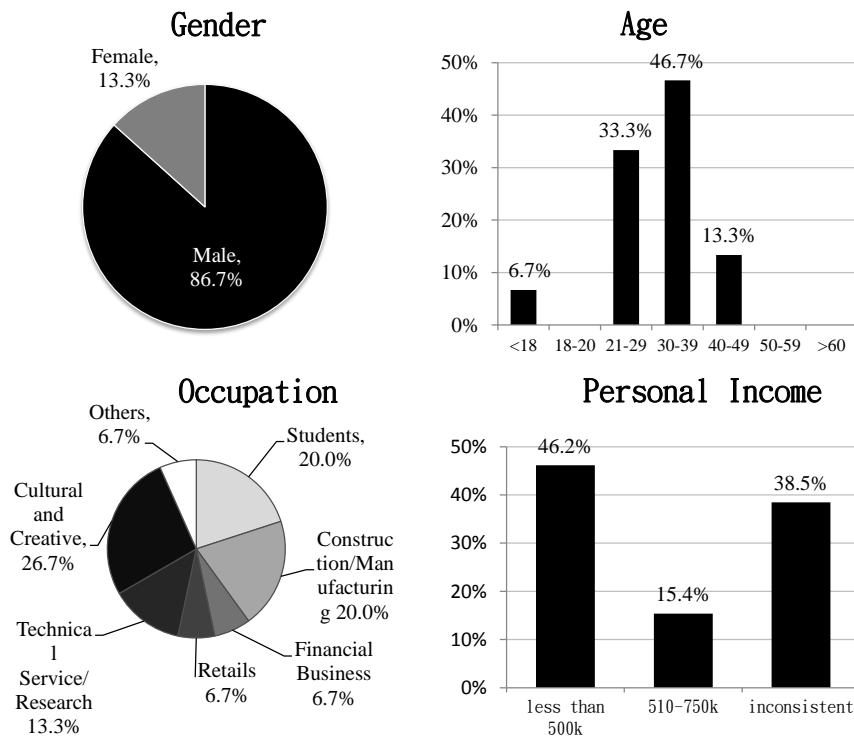


Figure 2. Makers' background

Most makers used 3D printers in maker space, and only about a half of them had 3D printers. To them, a reasonable price for a 3D printer for home use is about NTD\$30,000 (USD\$1,000) but they were willing to pay more than NTD\$44,000 (USD\$1,467) for their own 3D printers (Figure 3). Surface quality, easy calibration and maintenance were top three on the list of appealing characteristics, which are quite different from the results of the other survey (Table 1).

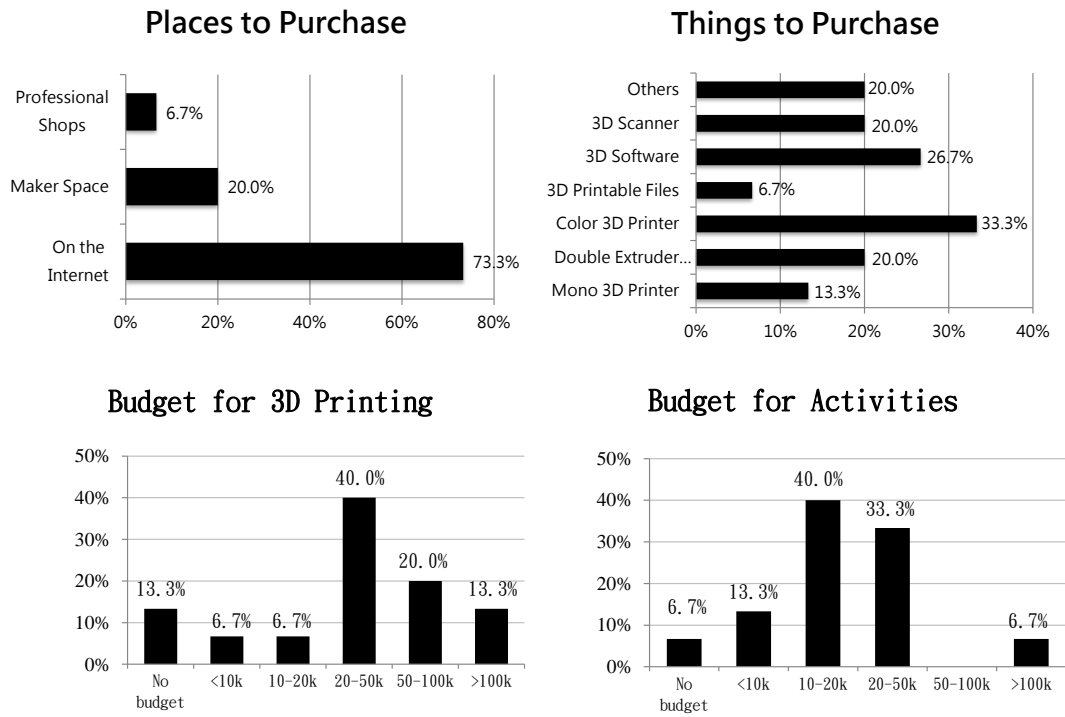


Figure 3. Consumers' behaviors for 3D printing

Table 1. Important Features for 3D printers

Important Features		
Rank	Feature	Score
1	Surface quality (Printing Precision)	1.9
2	Easy calibration	1.6
3	Easy Maintenance	1.6
4	Easy-to-use Software	1.2
5	Fast Printing	1.1
6	Open Source	1.0

Difficulty in use and lack of interests in the public were mentioned by 40% and 33% of makers respectively as main obstacles to 3D printing's popularity. Although makers' expectation about 3D printing's popularity in the general public is low (about 30%), they consider that maker movement and school education may help (Figure 4).

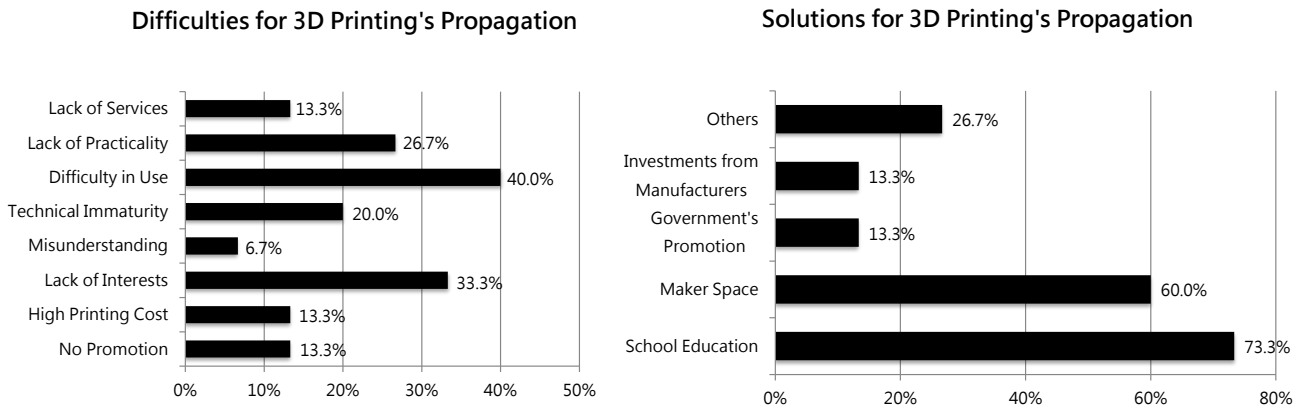


Figure 4. Difficulties and solutions for 3D printing

CONCLUSION AND DISCUSSION

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For needs of 3D future printing, a 3D printer within \$30K NTD was considered reasonable but it must be reliable, easy to maintain and manufactured products of good surface quality. User-friendly and easy-to-use 3D software was the second thing that might be attractive to potential 3D printing customers because most of them did not possess strong skills in 3D computer graphics. Big construction volume, color or flexibility in printing materials were secondary, from makers' point of view, to those customers' needs. Although quite conservative to 3D printing's popularity, makers consider school education and makers' movement in the maker space may contribute. Manufacturers and service providers may reference to their opinions and develop future 3D printing products and services accordingly.

ACKNOWLEDGEMENT

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